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THE CONTRAST IN THE FLORAS OF EASTERN AND WESTERN NEWFOUNDLAND¹

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The island of Newfoundland, with an area of more than 42,000 square miles, has a flora as yet only partially worked out, but sufficiently known to indicate a surprising degree of complexity in its makeup. The first impression gained by a casual observer in crossing Newfoundland is that the flora, as one visiting botanist has said, is an attenuated Canadian flora; but further study of the details and a careful daily record of observations on the plants of the island through several seasons of exploration has clearly emphasized that the *attenuation* of the Canadian element is one of the most conspicuous features of the Newfoundland flora. For, although lying in the latitudes of eastern Canada, Newfoundland has an almost negligible strictly Canadian element in its flora. The number of species characteristic of eastern Canada (Nova Scotia, New Brunswick, and the Gaspé Peninsula) and also found upon Newfoundland is made up primarily of such plants as extend their northeastern ranges along the north shore of the St. Lawrence quite to the Straits of Belle Isle and have obviously reached Newfoundland by crossing the narrow Straits.

Besides this meager Canadian flora which has been derived chiefly by way of its northeastern extension to the Straits of Belle Isle, the essential elements of the Newfoundland flora are three: (1) the arctic-alpine and Hudsonian elements, of somewhat broad distribution in the arctic regions or in Labrador; (2) the coastal plain element, a group of species abundant to the southwest of Newfoundland, chiefly in coastwise New England, Long Island and New Jersey; (3) the Atlantic European element, species characteristic of the region from the Baltic or the English Channel to the Mediterranean; while the endemic species and varieties are all closely related to members of the other four groups and should, in point of origin, be classed with them. As I have elsewhere shown,² the essential absence of the plants one

¹ Presented at the joint session of the Botanical Society of America and the Ecological Society of America at Pittsburgh, 1 January, 1918.

² *Rhodora*, 13: 141, 142. 1911.

would expect in Newfoundland, that is, the typical plants of the same latitude in eastern Canada, such species for instance as *Clematis virginiana*, *Asclepias syriaca*, *Populus grandidentata*, *Acer pensylvanicum* and *A. Saccharum*, *Eupatorium perfoliatum*, *Solidago squarrosa*, *Solidago juncea*, *Aster macrophyllus*, *Aster acuminatus*, etc., indicates that the flora of Newfoundland, except such species as have been derived across the narrow Straits of Belle Isle, has not reached the island by ocean currents or by winds, especially from the west and southwest; for, if these factors were important in carrying the western and southwestern plants to Newfoundland, we should expect such wind-distributed species as I have named and which are all abundant at the eastern edge of Canada to have reached Newfoundland amongst the first invaders.

A similar absence of the ordinary Canadian mammals and resident birds is conspicuous; for example, the common moose, red deer, porcupine, and spruce partridge, of all the Canadian forests opposite, are quite unknown in Newfoundland, and there the mammal- and resident bird-fauna is composed, like the flora, of species derived from Labrador or from the southwestern coastal margin of the continent, while certain land-snails have been pointed out as identical between Newfoundland and western Europe. In other words, the animal life of Newfoundland shows the same derivation as the plant life.

In explaining³ the migration to Newfoundland of a large element from the Atlantic coastal plain of the United States it has been necessary to reconstruct the Tertiary continental shelf, which is now depressed as a shallow bench off the east Atlantic coast of America; and from the botanical and zoological evidence, as well as from recently published geological evidence,⁴ it now seems perfectly settled that the continental shelf formed in the late Pleistocene and even later a nearly continuous although somewhat interrupted floor from New Jersey and southern New England, by way of Sable Island and the Grand Banks, to southern and eastern Newfoundland. And upon this floor the southern flora and fauna migrated to Newfoundland; but the unfavorable conditions of a sand-floor with meager forest and coastal plain bogs and barrens proved unattractive to the life of our rich Canadian forest, with the result that the forest species both of animals and plants, or the species which demand rich or basic soils, were for the most part unable to cross to Newfoundland.

³ Rhodora, 13: 135-162. 1911.

⁴ Barrell, Amer. Journ. Sci. IV. 40: 1-22. 1915.

The Atlantic European element in the flora would seem to be a relic from the early Tertiary flora which occupied the then dry northern floor of the Atlantic and which had persisted as a small remnant upon the Tertiary continental shelf and at the final submergence of the shelf became stranded upon Newfoundland, which, as is well known, is bordered by a tremendous shelf, the Grand Banks. The arctic-alpine and Hudsonian elements, as already intimated, have presumably entered Newfoundland in post-Pleistocene times by way of the narrow Straits of Belle Isle, which are commonly closed during the winter, thus forming a perfectly simple bridge from the north side of the Straits to the Newfoundland shore.

It is not, however, my intention to develop in this brief paper a theory in regard to the origin of the Newfoundland flora. The chief points I wish to emphasize are certain features which are of more practical and immediate interest to a group of ecologists. The most striking physiographical features of Newfoundland, so far as they impress the visiting botanist, may be very briefly summarized as follows.⁵ Extending from the southwest corner of the island at Cape Ray eastward for several miles, thence as a broad belt northward along the west coast to within 20 miles of the Straits of Belle Isle, is the Long Range of mountains. These for the most part are high tablelands of very diverse rock structure, the western tablelands and valleys and the broad foreland (20 miles wide at the north) being highly calcareous, consisting chiefly of limestones, marbles, calcareous slates, calcareous conglomerates, and in some areas of dolomite, traps and serpentines. The eastern ridges of the Long Range are chiefly granitic and they pass on their eastern flanks directly into a great central basin or low tableland of Archaean and chiefly acid rocks. This area, the Great Barrens or central tundra region of Newfoundland, extends, as observed from the train, for a distance of perhaps 100 miles west and east from the eastern flanks of the Long Range to the lower Exploits Valley. From the lower Exploits eastward and south-eastward the region becomes again rolling, but without any conspicuous mountains, except a few isolated granitic masses. In this southeastern region of the main island the rocks are essentially all acidic or highly silicious, so much so that the giant pulp and paper mills of the Harmsworth syndicate, located upon the lower Exploits

⁵ The most available brief account of Newfoundland physiography is a paper by Twenhofel in *Amer. Journ. Sci.* IV. 33: 1-24. 1912.

and about Notre Dame Bay, are forced to import all the limestone used in their mills from the west coast. The southeastern peninsula of Newfoundland, the Avalon Peninsula, separated from the main island by an extremely narrow and low isthmus which now consists chiefly of a flat peat bog, is, like the adjacent main island, composed essentially of silicious and acidic rocks. In the extreme southwest also, the region from Cape Ray to Bay St. George, the rocks are chiefly Carboniferous sandstones with little or no calcareous matter, or with such areas small and scattered, and covered extensively with acid peats. Projecting far to the north of the main island and bordered on the northwest and north by a broad foreland of horizontal limestones quite to the Straits of Belle Isle is the North Peninsula or Petit Nord; its interior practically unknown, but its western, northwestern and eastern tablelands almost exclusively of calcareous rock. Such, roughly, are the parts of Newfoundland as yet known to botanists, four distinct areas: the calcareous western region north of Bay St. George, and the North Peninsula; the acid central tundra region; the acid southeastern; and the acid southwestern sections.

So strikingly different are these areas in the composition of their flora that it is difficult to enumerate more than a few score of species which are generally distributed over the island. To the botanist who has spent a season exploring along the west coast, where the soils are calcareous and extremely fertile and the valleys sheltered and sunny, a transfer of base for another season to the southeast is like entering another world. The conspicuous elements in the flora of the west coast are the plants which we have come through long experience to associate with highly calcareous soils, while only upon such acid areas as the Carboniferous sandstones from Cape Ray to Bay St. George, the raw humus of mountain crests or peat bogs, or the granitic mountains at the eastern edge of the Long Range, do we find the plants commonly recognized as inhabiting acid or silicious areas. The valleys of the west coast have long been recognized as the most promising regions of the island for agriculture and adventurous and far-seeing young men from England and Ireland have undertaken extensive agricultural enterprises in the West; and during the past season the successful raising of wheat and the erection of a grist-mill in this region have been heralded by the Associated Press as epoch-making achievements. Contrasted with this favorable condition for agriculture, which prevails through the valleys and the lower levels of the

west coast, a region where fog and bleak winds are dispelled by the warm sun, is the condition in southeastern Newfoundland from Notre Dame Bay to the Avalon Peninsula. This eastern and southeastern coast is vastly more populous than the west coast, the people being chiefly fishermen and miners, but agricultural pursuits are almost negligible in this area. The Arctic Current, after following the Labrador coast, sweeps the east side of Newfoundland as a positive stream clogged into mid-summer with floe-ice and often closing the harbors to navigation; and experiences through several summers, reinforced by the statements of permanent residents, justify the statement that almost any day through the summer season one may look from the eastern shores with the prospect of detecting an iceberg. In other words, the east coast as contrasted with the west coast is bleak, foggy and with a subarctic climate; and the people of the east coast are severely handicapped even in raising potatoes and cabbages.

Now, turning to the vegetation of these two extreme areas, regions separated by 100 miles or more of tundra, we find that in the West the plants of the limestone valleys, talus slopes, brook ravines, river valleys, and open ledges are almost universally species of high northern distribution, occurring in western Newfoundland as outliers from a broad circumpolar range. Peaty or wet limy depressions of the west coast, for instance, are occupied by *Kobresia caricina*, a characteristic sedge of high-northern distribution, very rare in America except on the north side of the Straits of Belle Isle⁶ and in western Newfoundland, or with it *Juncus triglumis* or *Tofieldia palustris*, species which we rarely, if ever, see south of western Newfoundland. With these plants or on wet limestone slopes the calcicolous Saxifrages abound, *Saxifraga oppositifolia* (fig. 1), of the widest circumpolar distribution, extending southward on wet calcareous slopes to western Newfoundland, Anticosti, the Gaspé Peninsula, and the northern Green Mountains, and pushing south into the Canadian Rocky Mountains; or with these species *Saxifraga aizoides*, a characteristic plant of the Canadian Rockies, or *S. caespitosa*, of broad circumpolar range. Rocky ravines and shores of the western coast and the North Peninsula are made beautiful by that handsomest of willows, *Salix vestita* (fig. 2),

⁶ Contrary to the general impression that Labrador is a vast barren of Archaean gneiss, it should be pointed out that at the extreme Southeast, along the Straits of Belle Isle, the rocks are Cambrian limestones and sandstones; while the extreme Northeast consists of highly basic ranges of mountains.

a species unknown south of Newfoundland and the Gaspé Peninsula in eastern America, but very characteristic of the calcareous Canadian Rocky Mountains; while the driest of limestone shingle may be carpeted by the arctic-alpine *Salix reticulata*, a close relative of *Salix vestita*, but differing from it in various technical points. Similarly, on the calcareous shingle one is sure to find the handsome *Dryas integrifolia* (fig. 3), again of extensive distribution in the arctic archipelago and other regions of arctic America, but rare so far south as western Newfoundland; or *Potentilla nivea*, of more general arctic distribution and extending south into the Rocky Mountains and in the East as far as the coasts of western Newfoundland and the Gaspé Peninsula. With these plants the very striking *Lesquerella arctica* (fig. 4) abounds on the limestone shingle, again a plant of arctic range, found southward only in northeastern Labrador, on Anticosti Island, and in western Newfoundland; while these limestone plains and tablelands are the home of arctic-alpine Antennarias, Arnicas, Astragali, and various species of *Hedysarum*, *Gentiana*, *Campanula*, *Draba*, *Arenaria* and numerous calcicolous ferns. In the wetter valleys *Parnassia Kotzebuei*, of broad arctic distribution and local occurrence in the Canadian Rocky Mountains, is found and with it such characteristic Rocky Mountain plants as *Juncus longistylis*, *Cryptogramma Stelleri*, *Poa alpina*, *Cypripedium parviflorum*, and *Viola nephrophylla*, while occasionally a wet bank will be encountered covered with a dense carpet of the extremely arctic *Carex glacialis*, unknown elsewhere in America south of the arctic realm. These characteristic plants of western Newfoundland, then, are the species of high arctic-alpine range, abounding in America chiefly in the arctic archipelago or in the Canadian Rocky Mountains, both areas composed almost entirely of calcareous rock. This distinctive flora, which gives character to the west coast, consists of some hundreds of species which are quite unknown from the east coast or from the central tundra district.

When we come to the east coast the first impression of every traveler is one of excessive barrenness and untempered bleakness. In this region of acidic rocks the rich forests of the valleys of the west coast are not met. The trees are small and chiefly stunted, and plants which give the pronounced character to this region of subarctic aspect are very different from those of the west coast. On the peaty slopes of the hills of southeastern Newfoundland one finds himself divided in his mind as to whether the flora is more like that of the heaths of

England and western France or of the barrens of New Jersey, for here is a peculiar mingling of plants characteristic of the peats and silicious soils of Atlantic Europe and of the northern coastal plain of the United States. The peaty tracts are brilliant in August with the delicate, pearly-pink flowers of *Pedicularis sylvatica*, one of the most characteristic species of humus in western Europe, known nowhere in America except in southeastern Newfoundland, where it is accompanied in the peaty and heathy slopes not only by the heather itself, *Calluna vulgaris*, but by a unique grass, *Sieglingia decumbens*, a species of the peaty and heathy soils of Europe which in Great Britain bears the significant name "Heath Grass"; and one will find in southeastern Newfoundland with these characteristic European oxylophytes another of their European associates, the strong perennial *Potentilla procumbens*, resembling our *Potentilla canadensis*, but with many technical differences. This species, characteristic of western Europe, Madeira, and the Azores, is unknown in America except in the peaty slopes and wood-borders of southeastern Newfoundland and Cape Breton, although there is a vague early report of its having been collected in southern Labrador. Several other Atlantic European plants, altogether about 25 species, quite unknown in America outside eastern Newfoundland or occasionally Cape Breton or Sable Island, 100 miles off Nova Scotia, might be enumerated, but the species already mentioned are sufficient to indicate the Atlantic European element in the peaty soils of the region.

Associated with these plants one will find *Solidago uniligulata*, a characteristic plant of the New Jersey pine barrens; *Gaylussacia dumosa*, the coastal plain huckleberry, extending from the Gulf of Mexico around the entire coastal plain of eastern America; the inevitable cranberry, *Vaccinium macrocarpon*, which in the Yankee mind immediately suggests Cape Cod or New Jersey; or *Aster nemoralis*, a characteristic plant of southern New England and New Jersey. Turning to the more favorable habitats, the river-silts and -gravels, one will find likewise the strong European affinity in such species as *Juncus bulbosus*, unknown in America except in eastern Newfoundland and on Sable Island, while the coastal plain affinity is conspicuous in such plants as *Sisyrinchium gramineum*, abundant throughout the southeastern United States, becoming rare north of Massachusetts and quite unknown east of central Maine except as localized on Sable Island, the tip of Gaspé, and in southeastern Newfoundland; or

Panicum tennesseense, one of the most abundant grasses of the southern and southeastern United States, abounding eastward as far as Maine and western New Brunswick, but unknown from that region eastward until we come to the extreme eastern edge of Newfoundland. Turning now to the aquatics of eastern Newfoundland, these show exactly the same peculiar geographical ranges. The ponds and lakes of eastern Newfoundland are given over to such species as *Potamogeton polygonifolius*, the common pondweed of European heath-lands, of broad Eurasian distribution, but quite unknown in America except in southeastern Newfoundland and on Sable Island, or *Potamogeton Oakesianus*, the commonest pondweed of Nantucket and Cape Cod and found also southward into New Jersey.

So much, briefly, for the characteristic flora of the peaty open woods and slopes, the river-banks and ponds. The more exposed rocks and sand hills also show a strong coastal plain affinity. Everyone familiar with the open pine woods and sand hills of Atlantic United States knows the genus *Hudsonia*, represented by the two species, *H. tomentosa* and *H. ericoides*. Both of these species reach Newfoundland, but the latter, *H. ericoides* (fig. 5), is notable because it is found only in the extreme eastern portion of the island, where, like many other southern plants, it occurs on islands surrounded by nearly perpetual ice or ice-floe and fog. Thus, briefly, we have summarized the main floral elements of the characteristic acid southeastern region of Newfoundland.

Turning now to the central tundra district, we find, on referring to standard literature upon phytogeography, that the interior of Newfoundland is called a part of the arctic tundra; but this, like much of recent phytogeographic literature, is a statement prepared far away from and with a minimum of knowledge of the region described, for, although the region is certainly tundra, the most conspicuous thing about the tundra is the fact that it is not arctic. One of the larger ponds at the eastern edge of the tundra district bears the name, at once attractive to the visiting botanist, Rushy Pond. When our party was in this region, one of the first guesses was, inevitably, as to the particular rush which gave name to the pond. But after our experiences already in the region we all guessed alike, that it must be the common coastal plain *Juncus militaris*. The guess was correct and Rushy Pond was found to be bordered, like the ponds of New Jersey, Long Island and Cape Cod, by *Juncus militaris* (fig. 6), while

floating amongst the *Juncus* culms were the characteristic leaves and delicate flowers of *Nymphoides lacunosum*, with *Potamogeton dimorphus* and other southern species abundant. Going into the most characteristic tundra itself, for instance the vast tundra-region of bog and shallow pools near the station Quarry, one finds the arctic plants disappointingly few and only such species as are equally Hudsonian and Canadian in range. Pond-holes here, in the most highly developed tundra, are again full of *Juncus militaris*, or *Carex exilis*, *C. livida* or *Scirpus subterminalis* of the New Jersey pine barrens, while the pine barren *Potamogeton confervoides* fills the pools and the bushy patches are bordered by *Carex folliculata*, a species extending to Florida and Louisiana. In autumn, after the long August drouth, the little pools of the tundra have mostly dried away leaving peaty depressions which are carpeted with *Lycopodium inundatum*, *Eriocaulon septangulare*, *Bartonia iodandra*, the Newfoundland representative of the coastal plain genus *Bartonia*, *Schizaea pusilla*, the famous curly grass of the New Jersey pine barrens, *Xyris montana*, the northern outlyer of the austral and coastal plain genus *Xyris*, and many other southern species, the enumeration of which would become wearisome.

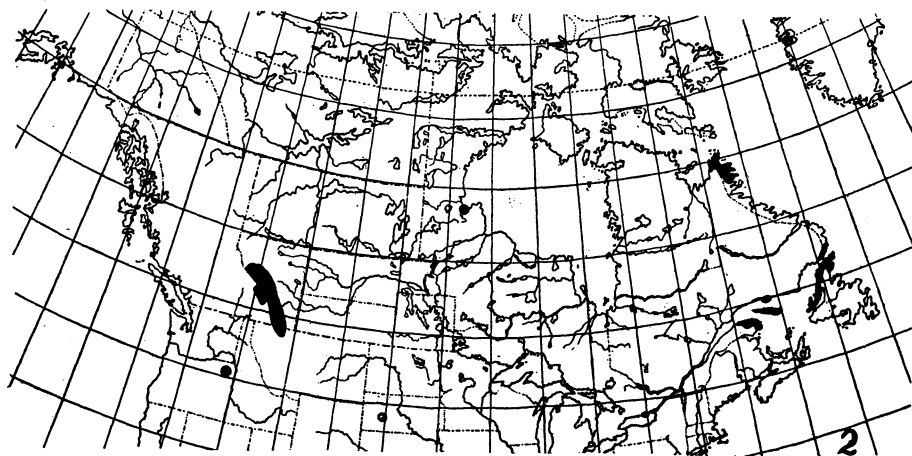
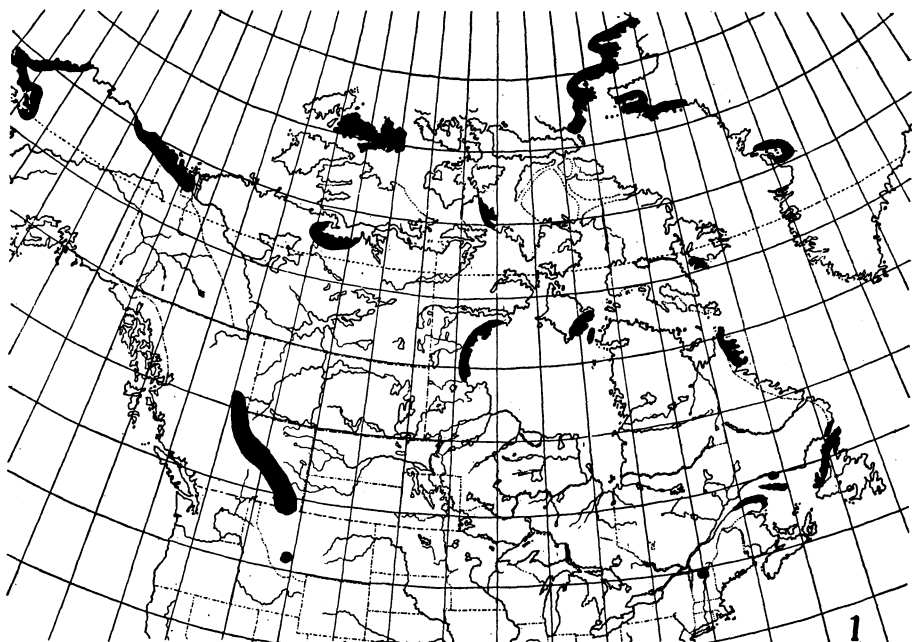
Similarly in southwestern Newfoundland, in the Carboniferous sandstones about Bay St. George, is a flora which is decidedly austral and disappointing to one who goes to the region looking for boreal plants: tremendous sphagnum bogs with an abundance of *Arethusa*, *Calopogon*, *Habenaria blephariglottis* or *Carex exilis*, just as if one were botanizing in New Jersey, while the drier areas furnish *Melampyrum lineare*, *Carex intumescens*, *Salix humilis*, *Diervilla Lonicera*, *Populus tremuloides*, and others making a tedious and uninteresting flora.

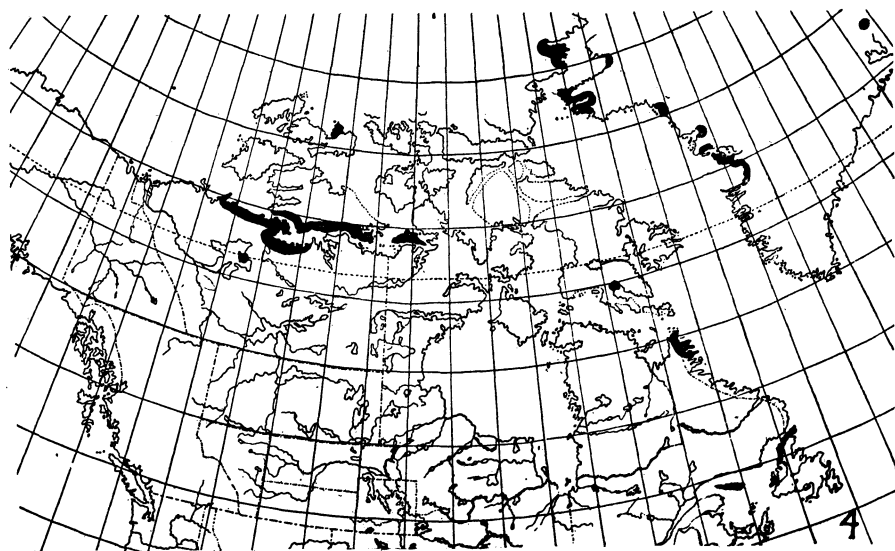
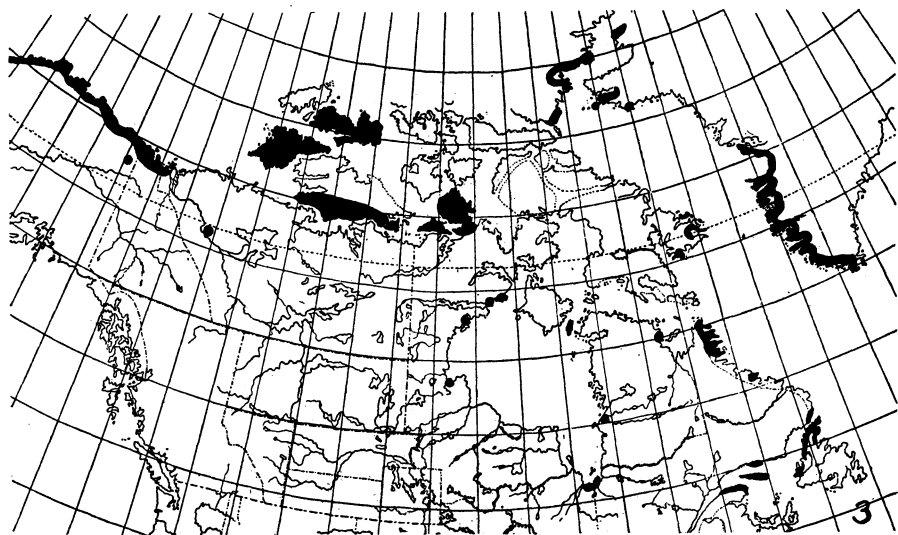
Now from this statement, which is a very brief summary of the conditions in the flora of Newfoundland, it must be apparent that the highly silicious or acid areas, such as the extreme eastern region of Newfoundland, the central tundra district, and the southwestern corner, are populated chiefly by plants of coastal plain origin with an admixture of species belonging primarily in the acid soils of Europe, which reached the island by way of the continental shelf; while the calcareous west coast and North Peninsula is characterized by a flora which finds its great development here and in the calcareous arctic archipelago and the calcareous Canadian Rocky Mountains. Yet the west coast with its arctic flora is the warm, sunny, and most fertile region of the island, while the east coast is the cold, bleak, and more

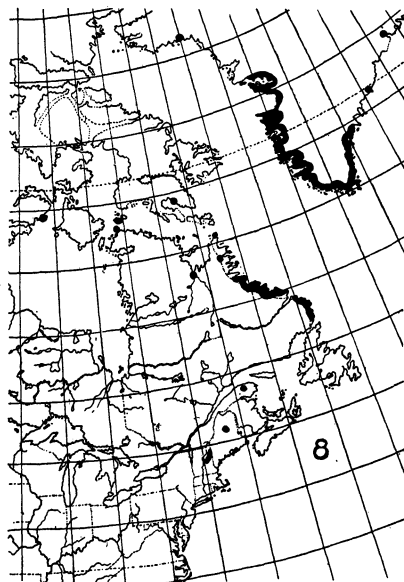
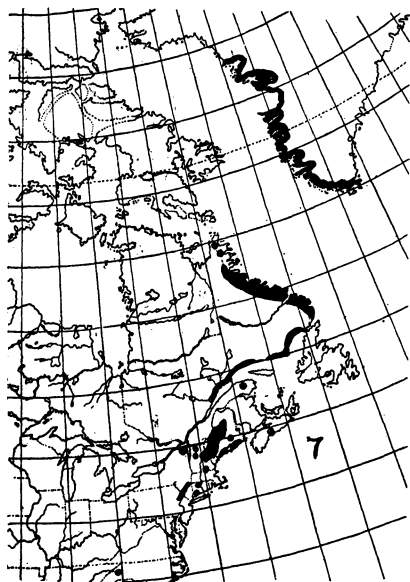
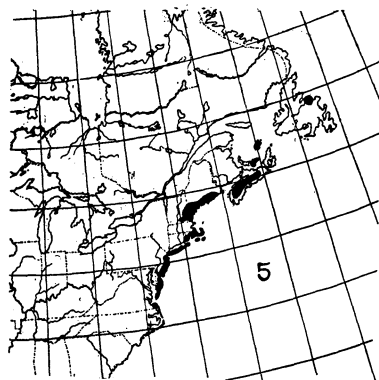
barren district. It is sufficiently evident to "him who runs" that the southern coastal plain plants, including such extreme austral genera as *Schizaea*, *Bartonia*, and *Xyris*, are in the acid regions of Newfoundland not because these regions are subarctic in climate but because the plants there find the acid soils which abound in the coastal plain region of the southeastern United States where these genera also occur. It is equally patent that the calcicolous arctic species which abound on the warm west coast of the island are there not because that is the warmest and most temperate region of the island, but because they there find the calcareous soils which are essentially like those in the other areas where they abound.

Now, as a corollary of this analysis one very striking feature comes out. This is the complete absence from acid central and southeastern Newfoundland of many Hudsonian and arctic-alpine species of acid Labrador and the granitic mountains of eastern Quebec, New England, and northern New York, species which are so general upon the mountains of New Hampshire and Maine and in the acid Labrador region that one would inevitably assume that they must abound in Newfoundland. Nevertheless, two centuries of botanizing in Newfoundland by hundreds of good botanists, ranging in acumen from Sir Joseph Banks and Bachelot de la Pylaie to the most humble amateur, has failed to reveal in Newfoundland such widely spread oxylophytes as *Arenaria groenlandica* (fig. 7), the commonest of plants on all granitic mountains of New England, as well as a widely dispersed plant of Labrador and Greenland; *Viola palustris*, which borders the mountain brooks of New England, the granitic Table-top Mountain of Gaspé, Labrador and the general northern regions; *Salix herbacea* (fig. 8), the little willow which carpets the wet humus of New England and Labrador mountains; *Cardamine bellidifolia*, abundant in sheltered pockets of granitic rocks of New Hampshire, Maine, Table-top Mountain, and acid northern regions; and so on through a long, long list. A few species such as *Poa laxa*, *Hierochloa alpina*, *Luzula spicata*, *Salix argyrocarpa*, *Betula glandulosa*, *Phyllodoce coerulea*, and *Cassiope hypnoides*, which are very abundant in all our granitic mountain regions of New England, Labrador, and the far North, have been found at one or, in rare cases, two isolated stations in Newfoundland. But it is obvious that they are rare and have just made their debut on the island.

In connection with this extreme paucity of the oxylophytic arctic-







alpine flora in the acid, bleak, subalpine central and southern regions of Newfoundland, it is noteworthy that the North Peninsula, which separates the vast acid area of Newfoundland by scores of miles from eastern Labrador, is itself essentially a limestone region. It thus would seem that, although these oxylophytes abound on adjacent Labrador, their first landing, when they are blown as seeds or fragments across the Straits of Belle Isle to the Newfoundland coast, would be upon a forbidding limestone soil. Consequently the majority of these species have not yet achieved a successful start, although they are doubtless blown to the Newfoundland coast many times during every winter. In a few cases seeds have succeeded in passing the limestone barrier and colonies are now starting as new occupants of the acid region.

From this brief analysis of the components of the Newfoundland flora it should be apparent, I think, that, if we are to get at the fundamental ecological laws, we must take more thoroughly into account than is generally done the elementary principle that many, if not most, plants are highly selective in their soil requirements. Explain away this point as we may, it constantly obtrudes itself, and it is certainly the part of wisdom to recognize facts as they are and to take as a working principle the general formula, that *the presence or absence of varying degrees of available lime or of other bases in the soil is more fundamental in determining plant distribution than are even considerable differences of temperature and humidity.*

GRAY HERBARIUM,
HARVARD UNIVERSITY

EXPLANATION OF PLATES XV-XVII

PLATE XV

1. American range of *Saxifraga oppositifolia*.
2. Range of *Salix vestita* (including varieties).

PLATE XVI

3. Range of *Dryas integrifolia*.
4. Range of *Lesquerella arctica* (including var. *Purshii*).

PLATE XVII

5. Range of *Hudsonia ericoides*.
6. Range of *Juncus militaris*.
7. Range of *Arenaria groenlandica*.
8. American range of *Salix herbacea*.